Institute for Materials Science

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Institute for Materials Science Lecture Series

Professor R. S. Markiewicz
Northeastern University, Boston

Excitonic Insulators in Correlated Materials

Thursday, May 19, 2016
2:00 - 3:00 pm
Wijiji Conference Room - MPA-CINT (TA-03 - Bldg 1420 - Room 2101)

Abstract: Shining light on a semiconductor can create excitons – bound states of electron-hole pairs, which lower the single particle gap E_G by the excitonic binding energy E_X. Four years after BCS theory, Mott showed that as E_G is decreased, there can be an instability when $E_G<E_{X,}$ leading to a condensation of excitons into an excitonic insulator (EI). There is a close analogy between EIs and superconductors, and the EI transition from semiconductor to semimetal parallels the BEC-BCS transition in a superconductor. One difference is that superconductors have been observed experimentally, while EIs remain strangely elusive.

An understanding of this phase is important in the study of correlated materials, since any model of vertex corrections quickly leads to the Bethe-Salpeter equation, which can be turned into a hydrogenic Schroedinger equation for exciton formation. In this talk I summarize a series of excitonic calculations of various levels of complexity, but all based on a full electronic dispersion rather than a parabolic model. Applications are made to transition metal oxides and slow graphene.

Bio: Bob Markiewicz got his Ph.D. in Berkeley in 1976, studying electron-hole droplets in Ge [Kittel, ISSP, 8th. Ed., Fig. 15.12]. After a two-year Post-Doc, he joined the Research Staff at G.E. in Schenectady, N.Y., where he studied graphite intercalation compounds and localization in ultrathin metal films. In 1980 he moved to Northeastern University in Boston, where he began studying cuprate physics in 1987, concentrating mainly on nanoscale phase separation and the role of the Van Hove singularity.

Around 2000 he began an ongoing collaboration with Arun Bansil at NU, to extend first-principles density-functional theories to study spectroscopies and more strongly-correlated materials. They initially studied ARPES [angle-resolved photoemission spectroscopy], and found that electron-doped cuprates were much simpler to understand, involving only (pi,pi) antiferromagnetism and superconductivity. He developed a form of DFT+GW calculation which could be applied to a variety of spectroscopies, including STM, optical, neutron scattering, and RIXS, and analyzed the competing-order phase diagrams of hole-doped cuprates, finding that LSCO is significantly different from other cuprates. He is now extending these calculations to include vertex corrections necessary to understand pseudogap physics.

He has also worked on SO(8), stripe physics, Fermi surface nesting, edge singularities in RIXS, and negative compressibility.

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Hosted by Alexander Balatsky * Director of the Institute for Materials Science

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